

2012 MCAS Exam Test Items

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Test item alignment to
Energy 1: Integrating Sciences through Energy
Questions 3, 13, 14, 24, 29, 31 & 43 directly align.

XXI. Technology/Engineering,
High School

High School Technology/Engineering Test

The spring 2012 high school Technology/Engineering test was based on learning standards in the Technology/Engineering content strand of the Massachusetts *Science and Technology/Engineering Curriculum Framework* (2006). These learning standards appear on pages 92–95 of the *Framework*.

The *Science and Technology/Engineering Curriculum Framework* is available on the Department website at www.doe.mass.edu/frameworks/current.html.

Technology/Engineering test results are reported under the following four MCAS reporting categories:

- Engineering Design
- Construction and Manufacturing
- Fluid and Thermal Systems
- Electrical and Communications Systems

Test Sessions

The high school Technology/Engineering test included two separate test sessions, which were administered on consecutive days. Each session included multiple-choice and open-response questions.

Reference Materials and Tools

Each student taking the high school Technology/Engineering test was provided with a plastic ruler and a Technology/Engineering Formula Sheet. A copy of this formula sheet follows the final question in this chapter. An image of the ruler is not reproduced in this publication.

Each student also had sole access to a calculator with at least four functions and a square-root key.

The use of bilingual word-to-word dictionaries was allowed for current and former English language learner students only, during both Technology/Engineering test sessions. No other reference tools or materials were allowed.

Cross-Reference Information

The table at the conclusion of this chapter indicates each item's reporting category and the framework learning standard it assesses. The correct answers for multiple-choice questions are also displayed in the table.

Technology/Engineering

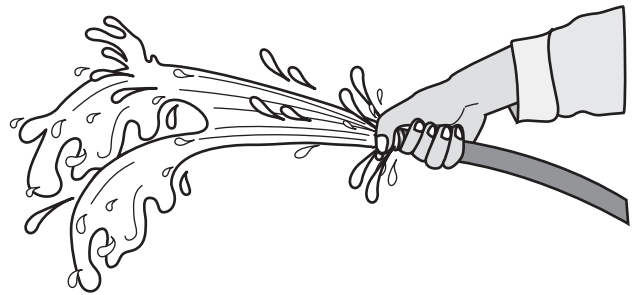
SESSION 1

DIRECTIONS

This session contains twenty-one multiple-choice questions and two open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

- 1 Juan is going to design a kite for mass production. After doing research, Juan creates several different designs and selects the one he wants to use.
- What are the next two steps Juan should do in the design process?
- A. Build and finish full-sized kites.
 - B. Redesign the kite and evaluate it.
 - C. Build a prototype of the kite and test it.
 - D. Patent the kite design and sell it to others.

- 2 A person is using a 1 in. diameter garden hose to wash his bike. The hose does not have a nozzle. To make the water spray, the person covers part of the hose opening with his thumb, as shown below.



After the person sprays the bike, he drops the hose to the ground. Which of the following statements describes the water coming out of the hose on the ground compared to when the person covered part of the hose opening?

- A. The density of the water is now less.
- B. The density of the water is now greater.
- C. The velocity of the water is now faster.
- D. The velocity of the water is now slower.

- 3 The thermal system of an office building should be designed to provide for the thermal comfort of the building occupants. To design the thermal system, an engineer first examines the interior environmental factors of the building.

Which of the following do **not** have a relationship that directly affects the interior environmental conditions of a building?

- A. total dead load and conduction
- B. average ceiling height and convection
- C. R-value of wall material and conduction
- D. number of windows per floor and radiation

- 4 The drawing below shows a doghouse.



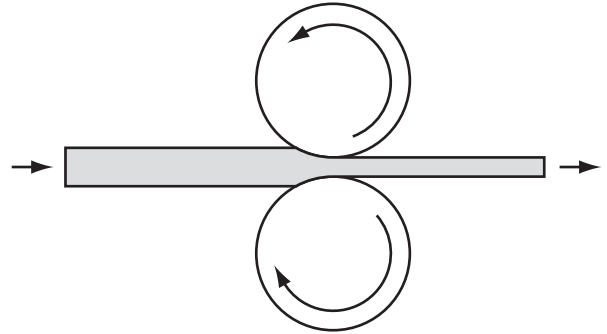
The roof area of this doghouse is 10 square feet. The doghouse is covered with a layer of snow that is 0.25 feet deep.

If the density of the snow is 6 lbs. per cubic foot, which of the following is the **best** estimate of the snow load on the doghouse?

- A. 10 lbs.
- B. 15 lbs.
- C. 25 lbs.
- D. 60 lbs.

- 5 Which of the following statements describes an advantage of total internal reflection within an optical fiber?
- A. It converts electrical signals into optical signals.
 - B. It converts optical signals into electrical signals.
 - C. It allows optical signals to be transmitted along a curved path.
 - D. It allows electrical signals to be transmitted along a curved path.

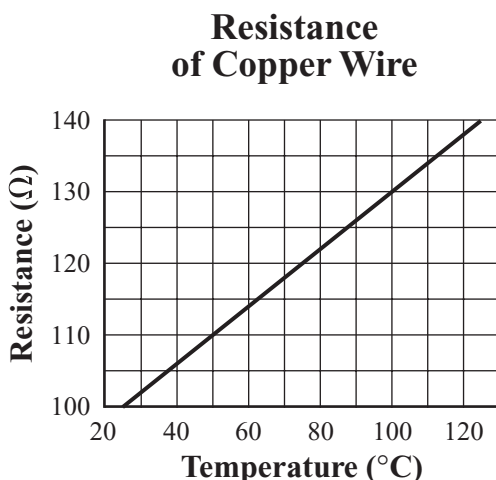
- 6 In the illustration below, a thick sheet of metal is being passed through two large rollers to produce a thinner sheet.



Which type of manufacturing process is being used?

- A. casting
- B. forming
- C. molding
- D. separating

- 7 The resistance of a coil of copper wire changes as the wire's temperature changes, as shown in the graph below.



What is the current at 50°C if the voltage is 12 V?

- A. 0.11 A
- B. 9.2 A
- C. 110 A
- D. 1320 A

- 8 A data encryption service developed in the early 1990s enabled a person to send e-mail that could not be opened by a third party. Over the years, this system has been improved and is now used in a variety of applications.

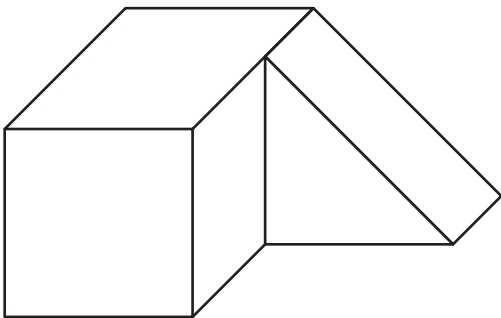
Which of the following statements describes a way this encryption service is used today?

- A. Individuals use it to prevent identity theft.
- B. Internet businesses use it to advertise via e-mail.
- C. Government agencies use it to regulate website fees.
- D. Designers of online games use it to enhance graphics.

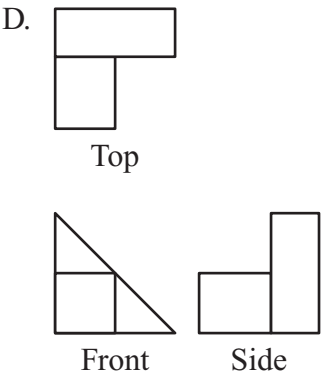
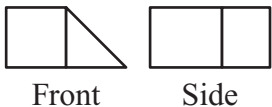
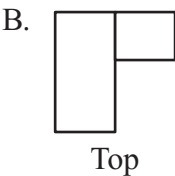
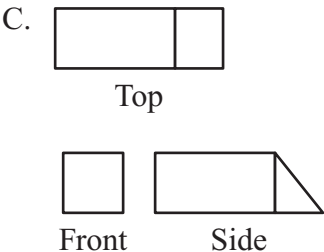
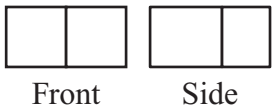
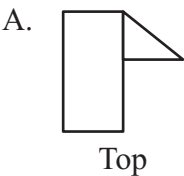
- 9 Which of the following statements **best** compares direct current (DC) and alternating current (AC)?

- A. AC flows in only one direction, and DC flows in both directions.
- B. DC flows in only one direction, and AC flows in both directions.
- C. AC comes directly from a power plant, and DC comes from a magnetic field.
- D. DC can maintain a constant voltage over time, and AC loses voltage over time.

- 10 A wooden part is shown below.



Which of the following orthographic projections best represents this part?

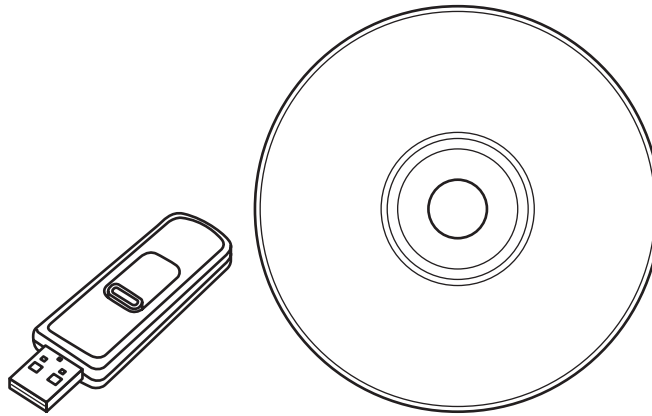


Question 11 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 11 in the space provided in your Student Answer Booklet.

- 11** The diagrams below show a USB flash drive and a compact disc (CD).



USB flash drive

Compact disc

Both USB flash drives and CDs are very durable compared to previous storage devices. USB flash drives have replaced CDs for many applications.

Describe **four** advantages of using USB flash drives rather than CDs to transfer data.

Mark your answers to multiple-choice questions 12 through 22 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

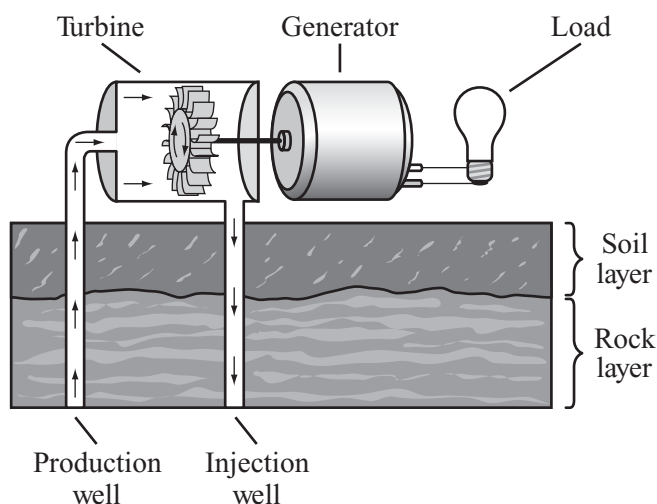
- 12 Which of the following explains why a sprinkler system is considered an open fluid system?

A. It uses water instead of air.
B. It allows water to evaporate.
C. It allows water to leave the system.
D. It recycles all the water within the system.

- 13 Which of the following explains why tinting office building windows is an effective way to reduce air-conditioning costs in the summer months?

A. Tinting absorbs heat from the inside of the building.
B. Tinting forces workers to use artificial lighting inside the building.
C. Tinting reduces the amount of solar radiation that passes into the building.
D. Tinting creates a thermal barrier that prevents heat from leaving the building.

- 14 The diagram below shows one system that can be used to generate electricity.

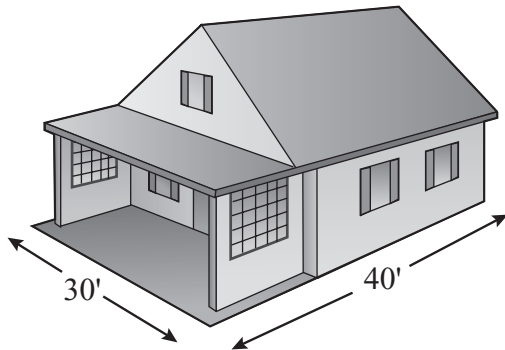


(Not to scale)

Which of the following renewable energy sources is being used to power this system?

A. geothermal energy
B. solar energy
C. water energy
D. wind energy

- 15 The diagram below represents a house.



An architect needs to produce a scale drawing of the first-floor plan of this house on a sheet of $8\frac{1}{2}'' \times 11''$ paper. Which of the following scales will allow the architect to make the largest drawing possible on one sheet of paper?

- A. $1'' = 1'$
- B. $\frac{1}{2}'' = 1'$
- C. $\frac{1}{4}'' = 1'$
- D. $\frac{1}{8}'' = 1'$

- 16 Which of the following best describes how information is coded in an analog signal?

- A. by blinking visible light for different durations
- B. by generating square waves consisting of ones and tens
- C. by varying the amplitude and frequency of electromagnetic waves
- D. by alternating electrical current between zero and a positive voltage

- 17 In the early twentieth century, a person in Boston, Massachusetts, who wanted to send a message to someone in San Francisco, California, gave the message to a telegraph operator. The operator tapped the message in Morse code, and the message was relayed through electrical cables to San Francisco. In San Francisco, an operator translated the signal into English and had it delivered to the address specified.

Which of the following describes the encoding process of telegraph communication?

- A. giving the message to the operator
- B. tapping the message in Morse code
- C. translating the Morse code message
- D. delivering the message to the address

- 18 A group of students is going to design and build a new set of shelves for a school. Which of the following describes the **first** steps of the design process that the students need to do?

- A. Draw a diagram of the shelf design on the computer, select the materials, and build the shelves.
- B. Find out why the shelves are needed, research current options, and brainstorm possible solutions.
- C. Measure the space for the shelves, select the possible materials, and get prices for the materials proposed for use.
- D. Brainstorm some ideas for the shelves, use the computer to design the shelves, and find the strongest materials to build the shelves.

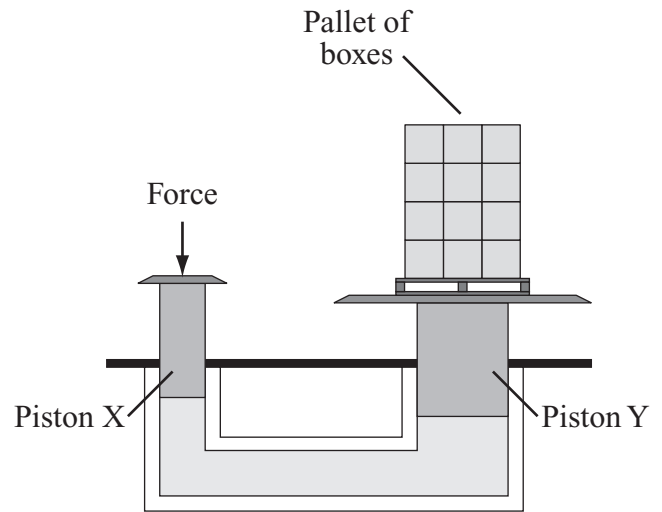
- 19 The foundation of a building carries the weight of the structure above it. Which of the following is the primary type of force on the foundation?

- A. compression
- B. friction
- C. shear
- D. torsion

- 20 For safety, a person using a power tool should comply with which of the following rules?
- A. Cut power by pulling on the electrical cord.
 - B. Use the tool only for the specific task the tool is designed to do.
 - C. Wear loose, baggy clothing that completely covers any exposed skin.
 - D. Make sure the power switch is set to ON before plugging the tool in.

- 21 Which of the following statements explains why hydraulic systems are generally more efficient than pneumatic systems?
- A. Hydraulic fluid is not corrosive, whereas pneumatic fluid is corrosive.
 - B. Hydraulic fluid is incompressible, whereas pneumatic fluid is compressible.
 - C. Hydraulic fluid has a low density and pressure, whereas pneumatic fluid has a high density and pressure.
 - D. Hydraulic fluid takes the shape of its container, whereas pneumatic fluid does not take the shape of its container.

- 22 The diagram below represents a hydraulic system.



When a force of 1700 lb. is applied to piston X, the 6800 lb. pallet of boxes moves upward. The hydraulic system serves as which of the following?

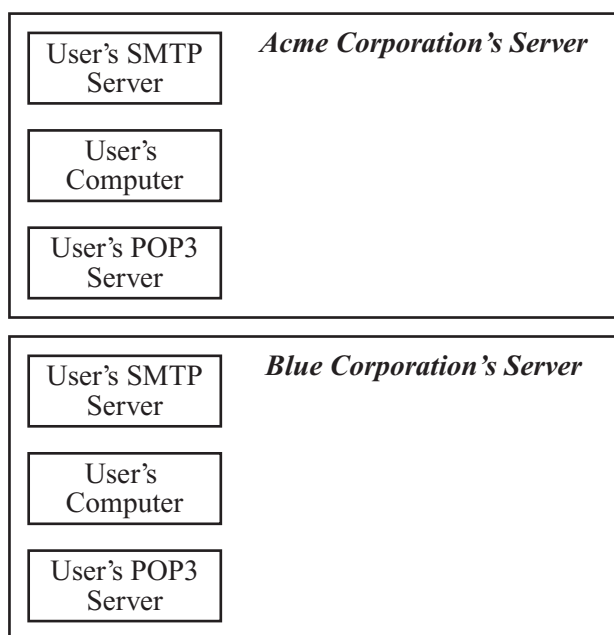
- A. area multiplier
- B. direction stabilizer
- C. force multiplier
- D. force stabilizer

Question 23 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 23 in the space provided in your Student Answer Booklet.

- 23** Many e-mail messages are sent through systems similar to the one outlined in the diagram below.



An SMTP server sends messages from its users and receives messages from other servers. A POP3 server holds a user's incoming messages until the user reads them.

- a. Copy the diagram into your Student Answer Booklet. On your diagram, add arrows to show the path of an e-mail sent from a user's computer at the Acme Corporation to a user's computer at the Blue Corporation.

A communication system can be made up of the following components: decoder, destination, encoder, receiver, retrieval, source, storage, and transmitter.

- b. Identify the part of a communication system represented by the user's computer at the Blue Corporation. Explain your answer.
- c. Identify the part(s) of a communication system represented by the POP3 servers. Explain your answer.

Technology/Engineering

SESSION 2

DIRECTIONS

This session contains nineteen multiple-choice questions and three open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

- 24 The table below shows R-values of several insulation materials.

| Material | R/Inch |
|--------------------|--------|
| cellulose | 3.70 |
| fiberglass batting | 3.20 |
| rigid fiberglass | 4.00 |
| rock wool | 3.03 |

Heat is lost from a building by conduction. Which material would be **best** to help prevent heat loss from a 4.5 in. thick wall?

- A. cellulose
- B. fiberglass batting
- C. rigid fiberglass
- D. rock wool

- 25 Solar photovoltaic energy is useful as a portable power source for items such as calculators. In a solar photovoltaic system, sunlight is directly converted into which of the following?

- A. heat
- B. electricity
- C. nuclear energy
- D. chemical energy

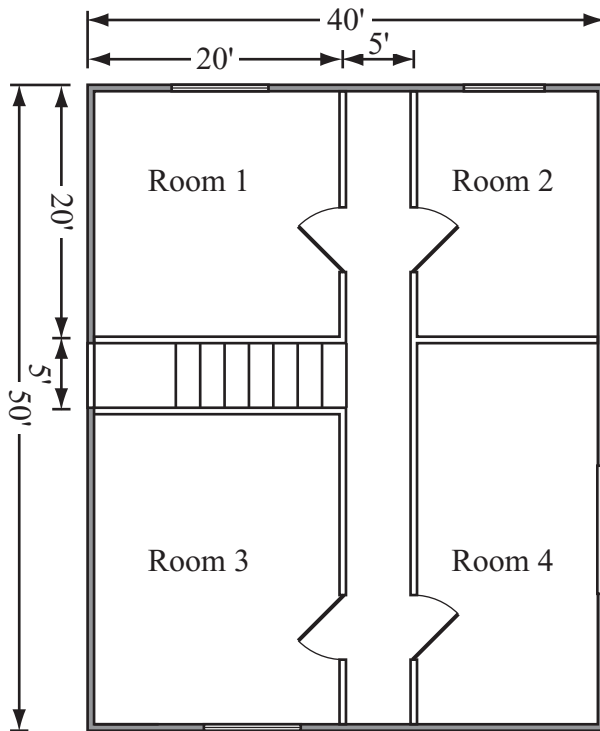
- 26 Which of the following types of systems most likely uses fluid under high pressure to operate?

- A. hydraulic
- B. thermal
- C. ventilation
- D. wastewater

- 27 Which of the following statements **best** describes how fiber optics is used to transmit information?

- A. Pulses of light are used to transmit digital information.
- B. Pulses of electricity are used to transmit digital information.
- C. Varying light frequencies are used to transmit analog information.
- D. Varying radio frequencies are used to transmit analog information.

- 28 The diagram below shows the second-floor plan of a house.



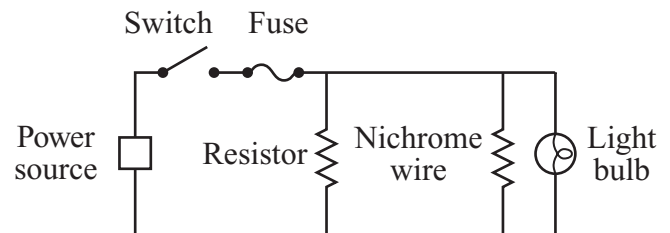
The builder will make the room with the largest square footage into the master bedroom. Which room will become the master bedroom?

- A. room 1
- B. room 2
- C. room 3
- D. room 4

- 29 Which of the following describes the winter conditions that would result in a home having the **highest** rate of heat loss to the outside environment?

A. a cloudy, calm day
B. several inches of snow on the roof
C. rows of icicles along the window awnings
D. a strong, steady wind blowing from the northwest

- 30 The circuit shown below consists of a power source, a switch, a fuse, a resistor, nichrome wire, and a light bulb.



When the power is on and the switch is closed, the light bulb does not light. Which of the following is the **most likely** explanation for why the light bulb does not light in this circuit?

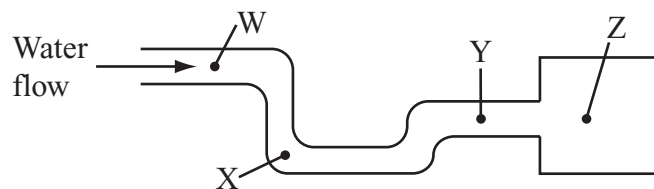
- A. The switch should be in the open position.
B. The nichrome wire does not conduct electricity.
C. The current flowing through the circuit has exceeded the rating of the fuse.
D. The placement of the resistor has created too much resistance in the circuit.

- 31 A teacher performs an experiment for a group of students. The teacher uses long, thin copper wires to connect a battery to a small light bulb. The teacher then applies heat to the copper wires. The students observe that the light bulb becomes dimmer. As the wires cool, the students observe that the light bulb becomes bright again.

Which of the following relationships is the teacher most likely trying to demonstrate?

- A. Light affects heat.
- B. Wire material affects voltage.
- C. Temperature affects resistance.
- D. Wire diameter affects transformation.

- 32 The diagram below shows a pipe system.



At which of the following points does water flowing in the pipe meet the **most** resistance?

- A. point W
- B. point X
- C. point Y
- D. point Z

Question 33 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 33 in the space provided in your Student Answer Booklet.

33 Fluid systems may be open systems or closed systems.

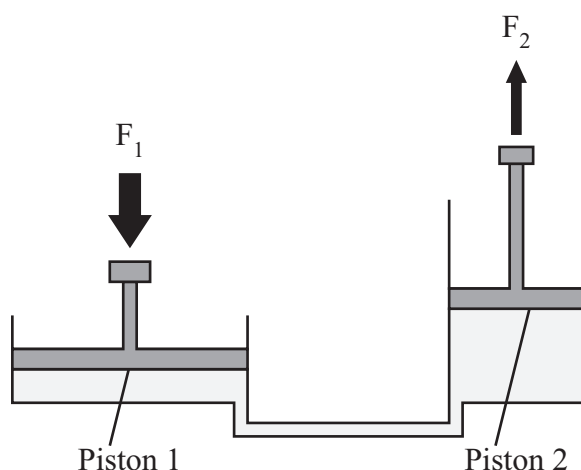
- Contrast an open fluid system with a closed fluid system.
- Provide one example of a closed system that contains a liquid.
- Identify whether the type of fluid in open systems is always liquid, is always gas, or can be either liquid or gas. Provide **two** examples to support your answer.

In a particular closed fluid system a liquid exerts a force of 360 lb. on a piston with a cross-sectional area of 12 sq. in.

- Calculate the pressure of the liquid in the system. Show your calculations and include units in your answer.

Mark your answers to multiple-choice questions 34 through 43 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

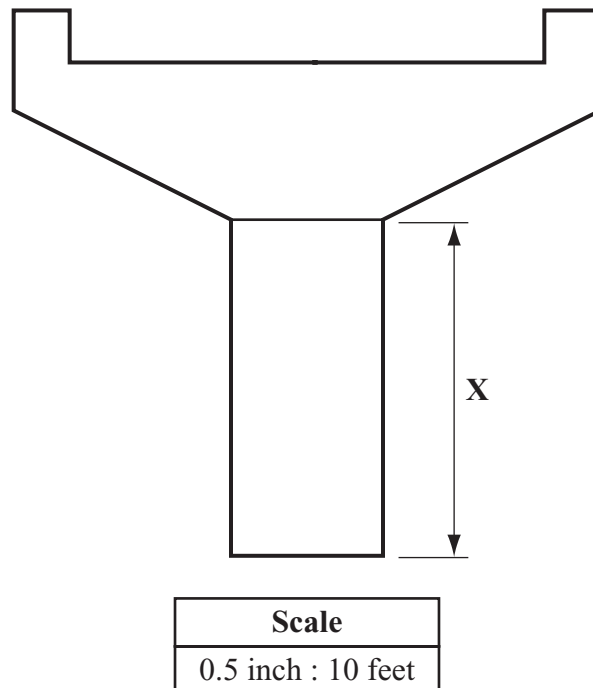
- 34 A hydraulic system with two pistons is shown in the diagram below. F_1 represents the force applied to piston 1, and F_2 represents the force exerted on piston 2.



The areas of the two pistons are represented as A_1 for piston 1 and A_2 for piston 2. Which of the following equations applies to this system?

- A. $F_1 + A_1 = F_2 + A_2$
- B. $F_1 - A_1 = F_2 - A_2$
- C. $F_1 \times A_1 = F_2 \times A_2$
- D. $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

- 35 The diagram below shows a vertical section of a support for a highway overpass.

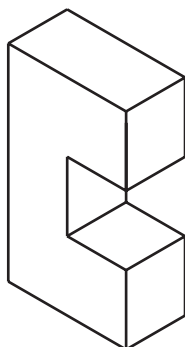


What is the height of the supporting column labeled X?

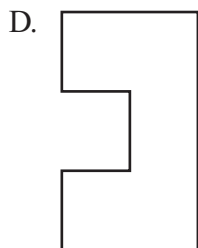
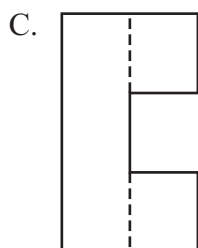
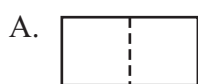
- A. 17 ft. 6 in.
- B. 35 ft. 0 in.
- C. 70 ft. 0 in.
- D. 87 ft. 6 in.

- 36 A company plans to design and manufacture rope that will be used for mountain climbing. Which of the following criteria is **most important** in selecting a material for the rope?
- A. plasticity
 - B. precision finish
 - C. R-value
 - D. tensile strength
- 37 Fiberoptic cables have not yet replaced copper wire cables as the most common means of Internet connection. Which of the following statements explains why copper wires are still used by many people to connect to the Internet?
- A. Fiberoptic cable networks are expensive to install.
 - B. Fiberoptic cables are susceptible to electromagnetic interference.
 - C. Fiberoptic signals cannot travel as far as copper wire signals without significant signal loss.
 - D. Fiberoptic signals travel more slowly than copper wire signals because of greater bandwidth.

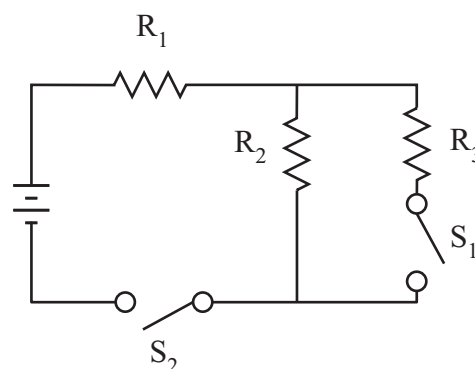
- 38 A drawing of a machine part is shown below.



Which of the following drawings shows the top view of the part?



- 39 A diagram for a circuit with two switches, S_1 and S_2 , is shown below.



If S_1 is left open and S_2 is closed, which resistors will be in series?

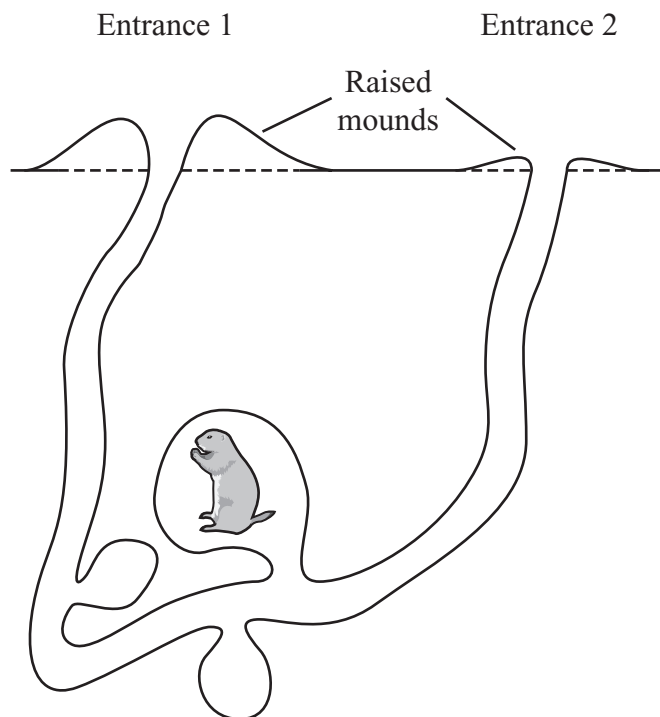
- A. R_1 and R_2 only
- B. R_1 and R_3 only
- C. R_2 and R_3 only
- D. R_1 , R_2 , and R_3

- 40 A bridge is to be built in New England and needs to withstand the region's very cold winters and hot summers. Which of the following properties of steel is **most** important in determining the design of the bridge?

- A. melting point
- B. strain rate
- C. thermal conductivity
- D. thermal expansion

- 41 Building codes in many cities require houses to have at least one open vent pipe that extends from the plumbing system through the roof of the house. Which of the following is a main reason for this requirement?
- A. to protect the house from fire
 - B. to allow fresh air into the house
 - C. to protect the roof from damage
 - D. to allow accumulated gases to escape

- 42 A prairie dog burrow is shown below.



Prairie dogs build raised mounds around both entrances to their burrow. The mound around one entrance is taller than the mound around the other entrance. Because the mounds are at different heights, the air pressure at entrance 1 is lower than the air pressure at entrance 2 when the wind blows. This causes air to flow in at entrance 2 and out at entrance 1.

In theory, the ventilation in a prairie dog burrow relies on which of the following concepts?

- A. Bernoulli's principle
- B. conduction
- C. Ohm's law
- D. pneumatics

- 43 Much of the heat produced by a fireplace is carried up the chimney by rising air. Which of the following processes is responsible for this loss of heat energy to the outside environment?

- A. conduction
- B. convection
- C. evaporation
- D. radiation

Questions 44 and 45 are open-response questions.

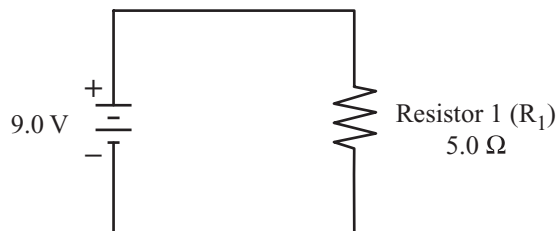
- **BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 44 in the space provided in your Student Answer Booklet.

- 44** An automobile manufacturer is considering the use of robotics to paint new cars.
- Provide **one** reason why using robots to paint cars might increase production compared with using human workers.
 - Identify and explain **two** other reasons, besides an increase in production, for choosing robots instead of human workers to paint cars.

Write your answer to question 45 in the space provided in your Student Answer Booklet.

- 45 A diagram for a simple circuit is shown below.



Ohm's law

$$I = \frac{V}{R}$$

Suppose a second resistor (R_2), with a resistance of 7.0 Ω , is added to the circuit in series.

- Draw the diagram for the series circuit with the two resistors. Label the components of the new circuit.
- Calculate the total amount of current in the new circuit. Show your calculations and include units in your answer.
- Calculate the potential difference (voltage) across each resistor, R_1 and R_2 , in the new circuit. Show your calculations and include units in your answer.

Massachusetts Comprehensive Assessment System Technology/Engineering Formula Sheet

Formulas

$$V = I \times R$$

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$P = I \times V$$

$$\text{Area of a circle} = \pi r^2$$

Variables

I = current

r = radius

P = power

R = resistance

V = voltage

Definitions and Abbreviations

AC = alternating current

psi = pounds per square inch

DC = direct current

$\pi \approx 3.14$

High School Technology/Engineering
Spring 2012 Released Items:
Reporting Categories, Standards, and Correct Answers*

| Item No. | Page No. | Reporting Category | Standard | Correct Answer (MC)* |
|----------|----------|--------------------------------------|----------|----------------------|
| 1 | 388 | Engineering Design | 1.1 | C |
| 2 | 388 | Fluid and Thermal Systems | 3.4 | D |
| 3 | 389 | Fluid and Thermal Systems | 4.2 | A |
| 4 | 389 | Construction and Manufacturing | 2.4 | B |
| 5 | 390 | Electrical and Communication Systems | 6.5 | C |
| 6 | 390 | Construction and Manufacturing | 7.1 | B |
| 7 | 391 | Electrical and Communication Systems | 5.3 | A |
| 8 | 391 | Engineering Design | 1.2 | A |
| 9 | 391 | Electrical and Communication Systems | 5.5 | B |
| 10 | 392 | Engineering Design | 1.3 | B |
| 11 | 393 | Engineering Design | 1.2 | |
| 12 | 394 | Fluid and Thermal Systems | 3.1 | C |
| 13 | 394 | Fluid and Thermal Systems | 4.3 | C |
| 14 | 394 | Fluid and Thermal Systems | 4.4 | A |
| 15 | 395 | Engineering Design | 1.4 | C |
| 16 | 395 | Electrical and Communication Systems | 6.2 | C |
| 17 | 396 | Electrical and Communication Systems | 6.3 | B |
| 18 | 396 | Engineering Design | 1.1 | B |
| 19 | 396 | Construction and Manufacturing | 2.2 | A |
| 20 | 397 | Construction and Manufacturing | 2.5 | B |
| 21 | 397 | Fluid and Thermal Systems | 3.2 | B |
| 22 | 397 | Fluid and Thermal Systems | 3.3 | C |
| 23 | 398 | Electrical and Communication Systems | 6.3 | |
| 24 | 399 | Fluid and Thermal Systems | 4.2 | C |
| 25 | 399 | Fluid and Thermal Systems | 4.4 | B |
| 26 | 399 | Fluid and Thermal Systems | 3.2 | A |
| 27 | 399 | Electrical and Communication Systems | 6.1 | A |
| 28 | 400 | Engineering Design | 1.5 | C |
| 29 | 401 | Fluid and Thermal Systems | 4.3 | D |
| 30 | 401 | Electrical and Communication Systems | 5.2 | C |
| 31 | 402 | Electrical and Communication Systems | 5.4 | C |
| 32 | 402 | Fluid and Thermal Systems | 3.5 | B |
| 33 | 403 | Fluid and Thermal Systems | 3.1 | |
| 34 | 404 | Fluid and Thermal Systems | 3.3 | D |
| 35 | 404 | Engineering Design | 1.4 | B |
| 36 | 405 | Construction and Manufacturing | 7.2 | D |
| 37 | 405 | Electrical and Communication Systems | 6.4 | A |
| 38 | 406 | Engineering Design | 1.3 | A |
| 39 | 406 | Electrical and Communication Systems | 5.1 | A |
| 40 | 406 | Construction and Manufacturing | 2.1 | D |
| 41 | 407 | Construction and Manufacturing | 2.6 | D |

| Item No. | Page No. | Reporting Category | Standard | Correct Answer (MC)* |
|----------|----------|---|----------|----------------------|
| 42 | 408 | <i>Construction and Manufacturing</i> | 2.3 | A |
| 43 | 408 | <i>Fluid and Thermal Systems</i> | 4.1 | B |
| 44 | 409 | <i>Construction and Manufacturing</i> | 7.3 | |
| 45 | 410 | <i>Electrical and Communication Systems</i> | 5.1 | |

* Answers are provided here for multiple-choice items only. Sample responses and scoring guidelines for open-response items, which are indicated by shaded cells, will be posted to the Department's website later this year.